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# Association between screen time, physical activity and sleep quality among youths

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**ABSTRACT**

To reduce the risk of contracting COVID-19 during the outbreak, the use of portable smart terminals (PST) among youths has increased significantly because youths prefer playing on their PST indoors. Hence, this article aims to study the impact of PST on youths' sleep quality and the effect of walking on improving sleep quality during the COVID-19 pandemic. A survey was conducted on the daily walking steps, sleep quality, and the use of PST among 312 ordinary youths aged 18-25. The control group kept their original lifestyle, while the experimental group walked 10,000 steps a day for 30 days. This study found that 88% of the respondents used PST for more than four hours. Also, the detection rate of sleep disorders among youths accounted for 39% of the total respondents. Compared to the control group, the sleep duration and quality of youths in the exercise group significantly improved ($p<0.05$). In conclusion, youths spend more time on PST and less time on physical activities, which worsens their sleep quality. Thus, by appropriately increasing their daily steps, the adverse effects of PST can be reduced, and the sleep quality of youths can be improved.



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## 1. INTRODUCTION

In general, an intelligent terminal is a piece of equipment with a built-in computer system that includes both hardware and software. However, portable smart terminals (PST) refer to all portable devices, including mobile audio-visual equipment, tablets, smartphones, and laptops. Presently, PST has altered the way youths communicate, access information, and participate in their surroundings. Especially during the COVID-19 pandemic, whereby to minimize the risk of virus infection, people reduced leaving their homes, walking or exercising. A previous study by [1] identified that the use of PST by youths increased during the pandemic and led to some youths developing an addiction to their PST.

According to Schmidt *et al*. [2] addiction among young people to PST, could progressively harm their physical health and physical function. Particularly those between the ages of 18 and 25 who are transitioning from adolescence to adulthood are more susceptible to weight gain and a loss in physical function [3]. Individual health behavioral habits formed during this transition therefore frequently endure into later life, thereby influencing the lifestyle of the individual, their partners, and/or their offspring [4]. The vast amount of time spent on PST typically leads to the selection of 18 to 25-year-old youths for this study.

It is also important to note that a person's physical and mental health, as well as their quality of life, are all evaluated by looking at how well they sleep [5], [6]. Hence, the government's "10,000 steps" campaign offers a precise and prescriptive idea of the necessary daily physical activity "dosage" [4].

Nonetheless, the COVID-19 pandemic lockdown phase had a negative effect on young people's levels of physical activity [7]. However, youths' sedentary lifestyles may be altered, thanks to the useful and enjoyable 10,000 steps programme, which can improve their health [8].

There is currently enough information to draw conclusions about youth screen usage during the COVID-19 pandemic in countries like the United States, Germany, Canada, Spain, Italy, and India [9]–[13]. China, the world's most populous nation, has been one of the nations most severely impacted by COVID-19. Hence, during the COVID-19 epidemic, this study examined the amount of screen time, levels of walking and sleep quality of young Chinese youths.

## 2. LITERATURE REVIEW

According to statistics, PST has 3.484 billion active users worldwide who log on for an average of 136 minutes every session [14]. Academics and the public are increasingly questioning such widespread PST use and its impact on human life. Researchers are concentrating on the negative effects of PST usage on one's health and psychology [15]–[17]. In addition, over the past five years or more, there has been increased interest in the link between excessive or problematic PST use and sleep-related problems. This attention can be linked to scholars' realization that the gradual blending of nocturnal and daytime PST consumption, particularly during periods of sleep latency, has occurred as a result of PST's gradual incorporation into human life [18]–[20].

Previous research concluded that such nighttime PST use can be harmful to people's health and wellbeing, particularly during the COVID-19 pandemic [21]. Similarly, it has been shown that a prolonged lack of physical activities or any exercise, for that matter is detrimentally associated to decreased cognitive functions, such as subpar scholastic performance [22], [23] and diminished daytime functioning [24], [25]. Hence, earlier research also reveals that a lack of physical activities may lead to numerous physiological problems, such as obesity and signs of mental disease like anxiety, depression, or low self-esteem, particularly during the COVID-19 pandemic [26].

Furthermore, it has been demonstrated that regular exercise improves youths' sleep quality. Therefore, being physically active during the COVID-19 pandemic and daytime can assist youths in feeling more physically exhausted, resulting in higher sleep quality and lengthier nighttime sleep cycles [27]. In addition, exercising has been shown to improve sleep efficiency, which refers to the amount of time spent asleep compared to the time spent in bed [4], [11]. Physical activities can also improve mental health, which enhances the quality of sleep by regulating the sleep-wake cycle and promoting more restful sleep and fewer sleep interruptions in young people [28]. Likewise, walking is known to improve youths' daytime alertness and decrease their daytime sleepiness. Therefore, youths may benefit from being more awake and alert during the day, which may result in better-quality sleep at night [17].

Especially during the COVID-19 pandemic, prolonged or excessive usage of PST among youths have been associated with negative sleep quality [19], [20], [25]. Moreover, the use of PST can disrupt youths' sleep patterns when notifications, alerts, and incoming messages interrupt sleep during the night, leading to fragmented sleep and decreased sleep quality. Also, youths may feel the urge to check their devices throughout the night, leading to further sleep disruptions and reduced overall sleep duration [27]. Likewise, [22], [28], [29] posit that the offset of the sleep period because of nocturnal PST usage may significantly shorten a person's sleep time. They also suggested that sleep deprivation can lead to various damaging health effects on youths, be it physically, emotionally, or mentally.

Similarly, youths may have psychological and emotional effects from using PST, particularly social media, such as elevated stress, anxiety, and depression. These unfavorable feelings may manifest during their sleep, resulting in disturbed nights and subpar sleep [14], [30], [31]. Furthermore, the use of PST may displace time that could be utilized on exercising or outdoor activities. Whereby, as an alternative to playing outdoors, sports, or other forms of exercise, youths may prefer spending more time on their PST [17]. Although up to date there are much literature concerning the effects of excessive PST usage towards reduced sleep quality and the effects of physical exercise towards improved sleep quality. Nonetheless literature on the health effects of low sleep quality due to PTS among youth and how walking can improve sleep quality is yet to be examined. Therefore, this study aims to examine the effects of PST usage in relation to sleep quality and the effect of walking 10,000 steps daily towards improved sleep quality among youths in China during the COVID-19 pandemic.

## 3. METHOD AND MATERIAL

### 3.1. Research subjects

From February to March 2020, 398 volunteers were recruited in Xiangtan City, Hunan Province, China. Among the 398 volunteers, 86 were not able to participate in the experiment because they were unable (n=35), busy (n=23), could not be contacted (n=17), and on medication (n=6), suffering from diseases (n=4), or physically disabled (n=3). Overall, 312 youths were selected for the research, they comprised of 164 males and 148 females, with an average age of 21.47±1.30 years old. Baseline data were obtained through questionnaires and the Pittsburgh sleep quality index (PSQI) scale was used to assess their sleep quality [27]. The research met the requirements of the university's ethics committee (approval code: 202001243). Also, all participants voluntarily participated in the experiment and have signed an informed consent letter.

### 3.2. Study design

The application timing software records the participants' usage of PST. In addition, the Huawei Band 3 Pro recorded the levels of all participants' daily walking and sleep related indicators (total sleep duration and deep sleep time) for 30 days. The values are averaged to measure their daily PST usage, physical activity, and sleep conditions. After 30 days, a stratified sampling method was utilized to measure sleep duration and sleep quality index. The 312 participants were divided into two groups, 156 participants were placed in the experimental group and the other 156 participants in the control group. There was no significant difference ($p>0.05$) on the sleep duration and sleep quality index between the two groups before the experiment. The control group maintained the original lifestyle, while the experimental group walked 10,000 steps per day under the guidance of professionals for 30 days. All participants used PST daily, had their daily average number of steps walked tracked and their sleep related indicators recorded. After the experiment, PSQI scale was used to reassess their sleep quality. Additionally, IBM SPSS statistics 25.0 was utilized for statistical analysis, independent samples T-test for Inter-group comparison, paired-samples T-test for fore-and-aft comparison and Spearman's correlation coefficient for correlated analysis ($\alpha=0.05$).

### 3.3. Test index

#### 3.3.1. Duration of use on portable smart terminals

To record the daily PST usage of participants precisely, a professional application timing software was utilised to record their use of PST, which is more reliable than the traditional questionnaire [28]. Also, to scientifically measure participants' daily use of PST, the data for 30 consecutive days was collected and averaged.

#### 3.3.2. Physical activities and sleep duration

To obtain accurate data pertaining participants' daily physical activity and sleep, the commercially available wearable device, Huawei Band 3 Pro was used to track their daily steps and their daily sleep related indicators (the total length of sleep and deep sleep duration). The device adopts HUAWEI TruSleepTM 2.0 scientific sleep technology which was developed in collaboration with the centre for dynamical biomarkers (CDB) of Harvard medical school to monitor overall sleep conditions more accurately. Additionally, the built-in low-power-consuming independent global policy and strategy (GPS) accurately records walking steps, calories consumption and walk trajectory. Therefore, it can accurately record the participants' daily walk and sleep related data. Hence, it is recommended that commercial wearable devices be integrated into future research on youths [29].

#### 3.3.3. Sleep quality assessment

PSQI was devised in 1989 by Dr. Buysse, a psychiatrist at the University of Pittsburgh. The PSQI is the gold standard questionnaire for assessing subjective sleep quality and has been validated in both clinical and non-clinical populations [30], [31]. There is evidence that the PSQI scale is also applicable for the evaluation of Chinese people's sleep quality [32]. Thus, PSQI was used to assess the sleep quality of participants during the COVID-19 pandemic. Overall, the Cronbach's alpha for internal consistency of this questionnaire was determined to be 0.872 [33]. It consists of 19 self-evaluations and 5 preceptor-evaluation items, among which the 19th self-evaluation item and 5 preceptor-evaluation items are not taken into scoring. Also, there are 7 components for the 18 scored items and each component is scored on a scale of 0 to 3. The scores of each component are accumulated and portrayed as the total PSQI score, ranging from 0 to 21. The higher the score, the worse the sleep quality. Whereby, if the total score is higher than or equals to 8, it means the sleep quality is poor. If the score is between 4 and 7, the sleep quality is medium. However, if the score is less than or equals to 3, it is good sleep quality [34].

## 4. RESULTS

At present, when PSTs are rapidly developing and highly popular, they become an indispensable part of today's youths (18 to 25 years old). Also, because PST has evolved from a basic communication function to a device that replaces the computer. Youths used PSTs for a long period of time and frequently [35]. Thus, it is evident that most youths on average use PST for more than 4 hours per day and account for 88.14% of the participants. However, during the COVID-19 pandemic, 20.20% of them use PST for more than eight hours per day as shown in Table 1. Calculated via the 24 hours a day measure, almost all the youths' free time is occupied by PST, with the exception for sleeping, eating, working or studying. Therefore, the lack of physical activity gradually affects the physical and mental health of youths.

Table 1. Description of the usage time, physical activity, sleep duration and sleep quality of youths' PST (n=312)

| | | Number | Percentage (%) | Mean±SD |
|---|---|---|---|---|
| Daily time spent on portable intelligent terminals | | | | 7.63±4.14 |
| | Below 2 hours | 9 | 2.88 | |
| | 2–4 hours | 28 | 8.97 | |
| | 4–6 hours | 103 | 33.01 | |
| | 6–8 hours | 109 | 34.94 | |
| | 8–10 hours | 50 | 16.03 | |
| | Above 10 hours | 13 | 4.17 | |
| Walking (steps) | | | | 6,536.08±1,423.29 |
| | Below 2,000 | 34 | 10.90 | |
| | 2,000–4,000 | 116 | 37.18 | |
| | 4,000–6,000 | 95 | 30.45 | |
| | 6,000–8,000 | 39 | 12.50 | |
| | 8,000–10,000 | 19 | 6.09 | |
| | Above 10,000 | 9 | 2.88 | |
| Sleep duration | | | | 7.29±3.16 |
| | Below 4 hours | 39 | 12.5 | |
| | 4–6 hours | 176 | 56.41 | |
| | 6–8 hours | 80 | 25.64 | |
| | 8–10 hours | 14 | 4.49 | |
| | Above 10 hours | 3 | 0.96 | |
| Deep sleep duration | | | | 2.32±1.03 |
| | Below 30 minutes | 9 | 2.88 | |
| | 30–60 minutes | 27 | 8.65 | |
| | 1–2 hours | 75 | 24.04 | |
| | 2–3 hours | 145 | 46.47 | |
| | 3–4 hours | 50 | 16.03 | |
| | Above 4 hours | 6 | 1.92 | |
| Overall PSQI score | | | | 6.86±2.32 |
| | Below 3 | 5 | 1.60 | |
| | 4–5 | 43 | 13.78 | |
| | 6–7 | 142 | 45.51 | |
| | Above 8 | 122 | 39.10 | |

Table 2 shows that the length of PST usage among 18 to 25-year-olds is negatively correlated with their sleep duration; whereby, the longer the PST usage, the shorter the sleep length. Thus, the average daily walking duration for the youths was positively correlated with the average sleep duration, with a correlation coefficient of 0.84, $p<0.05$. These findings show that the higher the average steps walked, the longer the average daily sleep length. Thus, the amount of average daily walking is one of the effective indicators for daily physical activity. Also, walking increases energy consumption, which increases fatigue, and makes them fall asleep fast and sleep longer. Furthermore, the length of PST usage among youths is positively correlated with the sleep quality index. This shows that the longer the usage of PST, the higher the sleep quality index. It indicates that the use of PST among youths has a bad influence on sleep quality. Additionally, the longer they use PST, the worse their sleep quality turns out. Thus, the results of this study identified that the average number of steps for 18 to 25-year-olds was negatively correlated with the PSQI, $r=-0.97$, $p\leqq0.01$ as presented in Table 2. Whereby, the more steps youths take each day, the lower the sleep quality index and the better the sleep quality. In summary, the impact of PST on sleep quality may be produced through the mediating effect of physical activity.

The participants were divided into two groups: control group (n=156) and experimental group (n=156). Youths in the control group kept their original lifestyle unchanged, whereas the youths in the experimental group exercised no less than 10,000 steps a day under the guidance of professionals. Therefore,

the average sleep time of youths in the experimental group was 7.29±3.16 hours before exercise and 8.26±3.38 hours after exercise as shown in Table 3. The sleep length of 18 to 25-year-olds walking 10,000 steps per day, increased significantly compared with their sleep length before exercise.

Table 2. Correlations among usage time of PST, walking volume and sleep quality (n=312)

| | Sleep duration (hour) | Sleep quality index |
|---|---|---|
| Length of use of portable intelligent terminals (hour) | -0.92* | 0.87* |
| Walk amount (step) | 0.84* | - 0.97** |

Note: *: P<0.05; **: P<0.01

Table 3. Comparative analysis of daily sleep duration and sleep quality indicators after 30 days of walking for in youths (mean±SD)

| | Groups | N | Before the experiment | After the experiment |
|---|---|---|---|---|
| Daily sleep duration (hour) | Control group | 156 | 7.31±3.17 | 7.18±2.96 |
| | Experimental group | 156 | 7.28±3.14 | 8.26±3.38 *# |
| Sleep quality index | Control group | 156 | 6.85±2.30 | 6.74±3.41 |
| | Experimental group | 156 | 6.87±2.31 | 5.93±2.03 **## |

Note: values are (mean±SD); *: significant difference compared to the control group, p<0.05; **: significant and large difference compared to the control group, p<0.01; #: significant difference compared to pre-experimental data, p<0.05; ##: significant and large difference compared to pre-experimental data, p<0.01.

## 5. DISCUSSION

Overall, sleep is a spontaneous and reversible resting state of the higher vertebrate in a cycle. It is manifested via a decrease in the body's responsiveness to external stimuli and a temporary interruption of consciousness. It is therefore noteworthy that humans spend about one-third of their life in sleep. Consequently, humans are always in an alternating state of awake and asleep, which is one of our biological rhythms. Generally, sleep plays the role of eliminating fatigue, protecting the brain, enhancing immunity, promoting growth, delaying aging and balancing the mental state [36]–[39]. Thus, to adopt a safe, practical, and effective way of exercising, walking has proven to be most suitable for all people [40]. However, in recent years, due to the rapid developments of PST, youths are focused on the prolonged usage of PSTs which leads to lesser physical activities and a decline in overall physical fitness [41]. Thus, according to Choi *et al*. [42] it is believed that 10,000 steps per day can maintain an ideal level of health and fitness.

Moreover, based on the findings of this study, during the COVID-19 pandemic, most 18 to 25-year-olds on average walked only 2,000 to 6,000 steps per day, this statistic is accounted for by 67.63% of all participants. Yet only 2.88% of all 18 to 25-year-old participants attained an average daily walking of 10,000 steps, and sadly, 10.90 % participants walked lesser than 2,000 steps per day as shown in Table 1, indicating that their daily physical activities were seriously insufficient. Therefore, poor sleep quality (too little or too much sleep) has been proven as a risk factor for obesity, diabetes, cardiovascular disease, depression, and mortality [43], [44]. Hence, the national sleep foundation recommends that youths sleep 9 hours a night to achieve optimal health and development [45]. However, the results of this study show that during the COVID-19 pandemic, most youths (18 to 25-year-olds) sleep on average about 4 to 6 hours a day. But only 5.45% of the youths sleep for 8 hours, and about 12.50% youths sleep for less than four hours a day as presented Table 1. Since sleep is of much importance to youths' learning, memory, and performance; adequate sleep can strengthen the immune system, which helps fight infection. Based on a previous study, male youths who slept ≥8.5 hours had the lowest average depression/anxiety risk. Nonetheless, shorter sleep duration among youths is related to increased depression and suicidal intentions [46]. Thus, poor sleep quality may be one of the causes of psychological problems such as anxiety and depression in youths.

Furthermore, previous studies have shown that deep sleep is particularly important throughout the sleep cycle [47]. Whereby, during deep sleep, human cerebral cortical cells are in a state of full rest, which plays an extremely vital role in stabilizing the mood, balancing mental health, and restoring energy [48], [49]. Table 1 shows that the youths (18 to 25 years old) with daily deep sleep of only 2 to 3 hours accounted for 46.47% of all participants. Only 17.95% of the participants attained deep sleep for more than three hours (Table 1). It shows that youths (18 to 25 years old) with short deep sleep hours cannot effectively restore their physical condition. It often manifests as daytime sleepiness, which is not conducive to normal learning [50]. Additionally, since PSTs emit light in the blue spectrum, it results in a reduction in melatonin secretion, which subsequently reduces deep sleep, or creates difficulty to enter a deep sleep state and has non-restorative sleep [51], [52]. At the same time, studies have shown that the use of PST may lead to reverse stimulation of sleep preparation [53]. Therefore, for 18 to 25-year-olds, reducing the use of PST before going

to bed may be one important way to promote good sleep quality and reduce psychological issues among youths.

Besides, based on PSQI, if the total score is larger than or equal to 8, the sleep quality is poor. If between 4 and 7, the sleep quality is medium (more than 5 means problematic sleep, which requires clinical detection) [34]. If the score is less than or equals to 3, it is considered as good sleep quality. The higher the total PSQI score, the lower the sleep quality level and the more obvious the sleep problem. The results show that only 1.60% of the youths' PSQI score was below 3 while those with scores of more than 5 accounted for 84.61% of the total participants. Their sleep disorder (score≧8) detection rate was 39.10% (Table 1). Research by Manzar *et al*. [54] Believes that sleep dysfunction brings more problems, for more people who do not realize that poor sleep quality has a complex relationship with overall physical health, including many mutual interactions among neurological, physiological, psychological, and behavioral factors. Thus, if no treatment is attained for sleep disorders, it can essentially be life-threatening [54]. Additionally, sleep disorders are associated with neurocognitive dysfunction, including attention deficits, impaired cognitive ability, depression, anxiety, stress, and poor impulsive control, which leads to reduced physical activity and poor academic performance [55].

As shown in Table 2, the length of PST usage among youths is adversely correlated with their sleep duration. One possible reason is that the PST owned by most 18 to 25-year-olds are mainly smart phones or tablet computers. Therefore, only a few youths have portable smart wearable devices. Also, most of the youths use smartphones and tablet computers to increase their screen time, which leads to a decrease in their overall physical activity level and affects their sleep quality. On the other hand, most youths aged 18 to 25 must do intense work or study during the day and are free only at night. Therefore, 9:00-11:00 pm is a relatively peak period for youths to use PST. However, the use of PST can lead to increased excitement in the sympathetic nervous system of youths, which in turn affects time for sleep and quality [56]. In contrary, walking promotes youths' energy consumption, which increases the fatigue of their body, reduces sympathetic excitability, increases parasympathetic excitability, reduces the secretion of thyroxine, adrenaline, and norepinephrine, and increases serotonin secretion, which help the body to fall into the state of sleep [38].

Finally, based on Table 3, under strict control of other conditions, for participants who walked 10,000 steps daily, their sleep quality index decreased significantly compared with that before exercise ($p<0.01$), On the other hand, compared with the control group, the sleep quality index of the experimental group was significantly lesser ($p<0.01$), indicating that 10,000 steps per day can effectively improve the sleep quality of youths (Table 3). After about one month of walking exercise, the self-control of youths had improved and their dependence on PST had significantly reduced. Moreover, the positive effect of good sleep quality is proven by the phenomenon of going to bed early, falling asleep fast, sleeping well, and feeling spirited after waking up. Ultimately, findings of this study show that walking 10,000 steps daily can effectively increase the sleep duration of youths. Also, compared with the control group, the sleep length of participants in the experimental group after doing exercise significantly increased ($p<0.05$), indicating that walking had a significant impact on the sleep duration of youths (Table 3). Therefore, it is established that walking 10,000 steps daily is essential to promote the consumption of energy, generate appropriate fatigue, help to fall asleep and improve sleep duration among youths.

In general, it's critical for parents, educators, and carers to develop healthy sleep practices and screen time limits to lessen the detrimental effects of PST on youths' sleep quality. Youths' sleep quality can be enhanced by establishing technology-free areas in the hour or two before bed, avoiding screens at least 30 minutes before bed, and encouraging a relaxing bedtime routine. Although youth who use PST can also benefit from increased knowledge of the value of sleep, instruction in responsible technology use, and the establishment of appropriate boundaries. It's critical that parents, teachers, and carers emphasize and promote regular physical activities like the 10,000 steps daily programme to reduce the potential harmful effects of PST on youths' exercise levels. This can entail restricting the amount of time spent on screens, planning regular pauses for exercise, encouraging outside play, and offering chances for organized sports or other physical activities. Consequently, youths can maintain a healthy and active lifestyle by striking a balance between technology use and physical activity.

The limitations of this research are that this study was conducted only among youths aged 18 to 25 years old. Thus, findings of this research cannot be generalized to other age groups. Also, the subject was centered on youths from Xiangtan City, Hunan Province, China; because it is an urban area, therefore, how far the findings of this study can be applied upon youths from sub-urban and rural areas is unknown. Additionally, no cluster survey on youths were conducted, therefore the sample coverage of this study was not of a larger number but based on the minimal required sample size. Consequently, in the future, the coverage of samples and the sample size could be expanded to conduct detailed cluster research on youths.

## 6. CONCLUSION

Conclusively, the daily 10,000-step exercise recommended does help youths fall asleep and improve their sleep length and quality. Especially during the COVID-19 pandemic, most youths used PST for more than four hours a day and their average daily walk were relatively low. Therefore, the longer the usage of PST, the shorter the sleep time and the inferior the sleep quality. This may be related to two factors: one is the use of a PST before going to bed, which will increase central excitability and decrease melatonin secretion, resulting in bad sleep quality. The second is the mediating effect of physical activity, whereby the increase in PST usage will reduce physical activity, thereby affecting the quality of sleep. Hence, this study suggests that youths should reduce PST usage and increase their physical activity time. These initiatives will help youths fall asleep, increase the total length of sleep and deep sleep, and improve the quality of sleep.

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